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## A R S

# FEED (and FOOD) GRAIN NUTRIENT COMPOSITION WORKSHOP

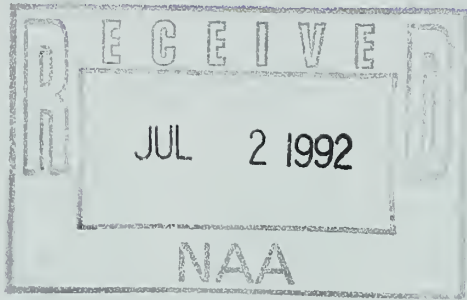
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**A R S**

**FEED (AND FOOD) GRAIN  
NUTRIENT COMPOSITION WORKSHOP**

**LIST OF PARTICIPANTS**





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Tuesday, May 5, 1992 (continued)

3:30 p.m.	Sorghum - Tentative Targets	J. F. Pedersen
3:45 p.m.	Sorghum - Discussion	J. F. Pedersen, Chm. C. L. Ferrell A. B. Maunder Audience
5:30 p.m.	EVENING BREAK	

Wednesday, May 6, 1992

8:00 a.m.	Corn - Tentative Targets	W. E. Kuhn
8:15 a.m.	Corn - Discussion	W. E. Kuhn, Chm. G. L. Alee N. C. Steele Audience
10:15 a.m.	BREAK	
10:40 a.m.	Wrap-Up	L. W. Smith C. F. Murphy Audience
11:45 a.m.	ADJOURN	



## PARTICIPANT INFORMATION

### ARS FEED (AND FOOD) GRAIN NUTRIENT COMPOSITION WORKSHOP

Dr. G. L. Alee  
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In his position as Unit Leader of Animal Sciences, Dr. Alee is responsible for the research, teaching, extension and international programs for all animal species. Dr. Alee continues to have a personal research interest in genetic modification of corn, sorghum, wheat and barley to enhance nutritional value as a feed ingredient for poultry and swine.

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In his position, Mr. Beck designs, develops and coordinates four databases of grain and forage crops. While acting as a liaison between Research, Production, Sales, and Marketing groups, he creates marketing opportunities and develops and administers sales force training. Key databases involve quality

grain traits (i.e., protein, starch and oil), corn silage (i.e., yield and digestibility), forage sorghums (i.e., yield and digestibility), and alfalfa (i.e., yield and quality with emphasis on harvest schedule relationships).

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Dr. Betschart is the Director of the USDA, ARS, Western Regional Research Center. The relevant research project is Nutritional and Health Promoting Properties of Cereal Foods (rice, oats and barley). Studies include identification of major constituents responsible for nutritional and health-promoting properties and the development of methods of isolating and/or concentrating these components.





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Dr. Buxton is the USDA, ARS Supervisory Plant Physiologist and Research Leader of the Field Crops Research Unit at Iowa State University. This unit conducts research on the biology of improving grain and forage crops. The unit studies the genetics of corn, soybean, and oat. Personal research is concerned with plant factors that influence availability of forage to ruminant livestock. Objectives are to (1) determine the influence of ecological factors on plant growth and development and on subsequent digestibility of forages; (2) identify physiological and morphological factors responsible for variation in digestibility and potential utilization of plants; and (3) determine the impact of altering concentrations of plant phenolics and lignin through breeding on plant digestibility and ability to survive diseases, insects, and other stressful environments.

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As Director, Research & Commercialization for National Corn Growers Association, Mr. Erker's responsibilities are in the area of

research that will lead to the eventual commercialization of new products made from corn. They are also interested in anything that will help the profitability of corn farmers.

Dr. Calvin L. Ferrell  
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Dr. Ferrell is a Supervisory Research Animal Scientist with the USDA, ARS Roman L. Hruska U.S. Meat Animal Research Center. As Research Leader, Dr. Ferrell's program is focused on digestion, absorption and utilization of nutrients, particularly energy and protein, for maintenance, growth and reproduction in cattle, sheep and swine.

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Dr. George Fohner is the President of RSI - Resource Seeds, Inc. RSI breeds and develops markets for feed and food crops including barley, oats, and triticale. His responsibilities include determining research objectives and working with growers and users of grain to develop identity-preserved markets for their varieties.



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Dr. Frey, Iowa State University, is a Distinguished Professor in Agriculture. He is a plant breeder responsible for developing oat varieties with value-added traits.

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Dr. Robert Friedman is Associate Director of Research for American Maize-Products Company. His responsibilities and interests include directing research into developing new genetic varieties of maize to produce starch and other products with enhanced and controlled functionalities. Functionalities include nutritional aspects as well as utility in food systems.

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Dr. Froseth is a Professor of Animal Science at Washington State University. His primary research interest is the nutritional quality of barley for non-

ruminant animals, especially swine and poultry. Specifically, his research group has studied components in barley including fiber fractions,  $\beta$ -glucans, starch type and arabinoxylans that affect its utilization and energy value. They have perfected the use of the mobile nylon bag technique to screen small quantities of new barley lines from Dr. Steve Ullrich's barley breeding program for nutritional quality. They have also studied production and dietary factors that influence barley quality and utilization including: barley type, cultivar, geographical location of production, irrigation, fertilization, grain processing and enzyme supplementation of barley diets. They have just completed an extensive study of the nutrient composition of barley grown in the Pacific Northwest and have compared the results to NRC values.

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Dr. Gerloff serves as the Associate Director, Midwest Area, which employs over 1200 employees at 14 locations in the states of Minnesota, Missouri, Iowa, Wisconsin, Illinois, Indiana, Ohio, and Michigan. In this capacity, he participates fully with the Area Director in the management of the budget and in planning, coordinating, and evaluation of overall research programs. The research includes such disciplines as animal diseases, plant and natural crops







research, soil and water management, insect and weed control, plant physiology and genetics, avian diseases, and food quality and safety research.

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Dr. Hunt's responsibilities at the University of Idaho are 50% teaching and 50% research, with a specialized interest in ruminant nutrition. Research has

focused on nutritional value of feedstuff commonly fed to ruminants and the effects nutritive differences have on ruminal digestive function. A study was completed examining the nutritional divergency of barley sampled from throughout the Pacific Northwest representing numerous different varieties. Quantification of chemical and ruminal degradability differences among barley samples was attempted using near infrared reflectance spectrophotometry. Further studies are in progress to evaluate ration formulation strategies of barley sources differing in chemical composition. These studies involve comparison of corn and barley type as provided in forage-based diets and beef cattle finishing diets. Studies involving barley are intended to identify nutritionally important traits and proper uses of the various grain types in ruminant ration formulations.

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Dr. Hunter is Vice-President Research for Ciba-Geigy Seed Division. They are involved in plant breeding and biotechnology research on corn and soybeans and are interested in participating in the development of these crops for expanding and specialized markets.



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Dr. Isgrigg is the Administrator and Director of Marketing for the Washington Barley Commission. His responsibilities include all aspects of the function of the Commission--promotion of barley usage in the feed and food industries of the U.S.; directs and oversees research sponsored by the Pacific Northwest Barley Commissions; instituted the development of the first nutritional testing procedure for the PNW Barley Breeding Program. Dr. Isgrigg is on the steering committee for the North American Barley Genome Committee that has over 25 scientists throughout the U.S. involved in the mapping process. He had his organization fund an extensive testing of factors of modern barley cultivars as it relates to the feeding and food industry. Dr. Isgrigg is on the Pacific Northwest Animal Nutrition Committee.

Mr. A. F. Kertz  
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A. F. Kertz is Manager of Nutritional Consulting and Applied Research, Dairy Business Group, Purina Mills, Inc., St. Louis. Al has been with Purina since 1973, primarily in dairy or ruminant research until July, 1990, when he assumed present responsibilities for

Purina's Field Dairy Consultant Program, Technical Service, and Applied Research at both Gray Summit Research Center and Field levels.

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Dr. Kleese is Product Development Manager, Specialty Plant Products Division at Pioneer Hi-Bred International. His responsibility at Pioneer is to help identify market opportunities for value added crop varieties and hybrids so the company can decide which of those opportunities merit the research and business investment. He is particularly interested in improved nutritional quality in cereals.

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Dr. Bill Kuhn is the Assistant Director, North American Corn Breeding Department at Pioneer Hi-Bred International, Inc. He has oversight of Pioneer's corn breeding effort in the specialty or value added area. This would include improved nutritive quality in corn. Pioneer also has interest in mold/mycotoxin resistance of their grain. His role is in the plant breeding side.





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Ms. Martinez is the USDA, ARS Associate Deputy Administrator of Agriproducts and Human Nutrition Sciences, National Program Staff, and as such is responsible for the ARS agriproducts and human nutrition sciences research programs. In her former position as National Program Leader, Mrs. Martinez functioned both as a team member and a team leader for her area of responsibility--product quality--to develop, prioritize, and allocate resources to national problems and

research objectives that are responsive to the concerns and needs of USDA Action and Regulatory Agencies, national trade groups, consumer groups, the Congress, and the Secretary of Agriculture. Research programs, once established, are evaluated on a timely basis for relevance and rate of progress. Mrs. Martinez is a member of numerous scientific associations, including the American Chemical Society, American Oil Chemists Society, American Association of Cereal Chemists, Federation of American Societies for Experimental Biology; and serves as exofficio member of several commodity research committees including the National Cottonseed Products Association, American Soybean Association, National Peanut Council, and the Wheat Classification Working Group.

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Dr. Maunder is Senior Vice President for Sorghum & Tropical Maize Research. His responsibility involves the determination and direction of research priorities in both sorghum and tropical maize that will lead to improved commercial products. In the case of sorghum always being in a second position such as to cotton in the south, wheat in Kansas, and corn in Nebraska, a major objective has been to develop a product that more satisfactorily meets the





need of the livestock producer. His international responsibilities with US/AID as chairman of the External Evaluation Panel have allowed Dr. mauder an opportunity to look closely at ways of improving grain quality from a food standpoint for third world developing countries. Plant breeding and germplasm resources have been principle interests during his 32+ years of commercial plant breeding.

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Dr. Arline McDonald is a research scientist with Quaker Oats Company. Her background is in human nutrition research with an emphasis on health promotion (nutrient requirements as they relate to prevention of disease). At Quaker Oats, Dr. McDonald is involved with design and implementation of clinical and experimental research involving grains--specifically oats--and grain components and their physiological effects.

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As Regional Agronomist, Corn Production Specialist, Dr. Nelson heads up specialty grain for Cargill. He is especially interested in the specific end uses of various grain commodities involving starch, protein, and oil. Bringing together producer and consumer...finding new and innovative ways to process and move basic goods and services efficiently and economically...drawing upon years of knowledge and experiences to meet the needs of today and prepare for the challenges of tomorrow...these are the traditions and commitments of Cargill. Finding new uses for cereal grains and their products to help improve the world's standard of living is a basic philosophy of Cargill.

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Dr. Newman is a Professor of Animal Nutrition at Montana State University. His major responsibility at the university is in the area of monogastric nutrition, primarily swine. Although swine have received most of his attention, he has

worked with poultry and ruminants to some extent. The major focus of his research for the past 27 years has been the evaluation of barley as a feed grain and the factors that affect the composition and consequently nutritional quality. More recently his research interest has been expanded to include barley for human food. His research group is evaluating the effects of cultivar and environment on the nutritional components of commercial barley varieties and selected cultivars having unique characteristics including hull-less, high-amylose starch, high-lysine protein, waxy starch and high fiber ( $\beta$ -glucans).

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Dr. Rosemary Newman is a Professor of Foods and Nutrition at Montana State University where they have the capabilities of chemical analysis of grain, biological testing of nutritional quality through animal studies and some rudimentary food science activities. She has actively promoted barley as a food grain, and has been in contact with numerous individuals in various aspects of barley food applications. Barley can be separated into fractions by milling and/or air classification to obtain greater concentrations of fiber and oil. The shorts and bran fractions can effectively be utilized in food products with increased fiber content. Brewers grains can likewise be utilized as fiber



supplements. Barley is appropriate for a wide variety of food applications. Because of its divergent genetic properties, the specific cultivars best for specific purposes need to be further explored. Two consistent problems for food manufacturers who are interested in using barley are: (1) to identify the best cultivar for the product; and (2) to locate a source offering adequate supply of that cultivar.

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Dr. Robert R. Oltjen (Bob) is Associate Deputy Administrator, Agricultural Research Service (ARS). In this position, Dr. Oltjen is responsible for the ARS animal sciences research program. Animal nutrition is a part of this program. Dr. Oltjen has had a long standing interest in animal nutrition, having been a ruminant nutritionist, served on the Committee on Animal Nutrition, NRC, and directed the Meat Animal Research Center, Clay Center, Nebraska, before coming to his current position.

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Dr. Pedersen is a Research Geneticist with USDA, Agricultural Research Service at the University of Nebraska, Lincoln. His major research emphasis is improvement of sorghum feed quality through breeding. Current research addresses development of feed quality assays, NIRS calibration, and development of genetic information about sorghum feed quality.

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Dr. Peterson is a Supervisory Plant Physiologist with the USDA, ARS, MWA Cereal Crops Research Unit. His responsibilities and interest include (1) supervisory responsibility over protein evaluation of breeders' oat lines; (2) analysis of oat and barley samples from National Small Grains Collection for beta-glucan and protein, (*oil analysis of oat samples will be added soon*); (3) research on physiochemical characteristics of beta-glucan and other fiber constituents of oat and barley; and (4) analysis of oat and barley samples for tocopherols, minor oil constituents that have cholesterol-lowering properties, and effects of genotype, environment,





development and tissue on levels.

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Dr. Qureshi is a Collaborator with the Cereal and Crops Research Laboratory in Madison, Wisconsin. He has been isolating and identifying a number of new tocotrienols as very effective cholesterol inhibitors from cereals (barley, oat and rice) and palm oil for the past several years. These cholesterol inhibitors have been demonstrated either as a mixture of various known or unknown tocotrienols or individual component as effective in lowering the serum total cholesterol and low density lipoprotein (LDL) cholesterol of hypercholesterolemic human subjects, chicken and swine. All these compounds are purified by using novel techniques of Bond Elut column purification coupled with high pressure liquid chromatography.

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Dr. Ramage is a Research Geneticist with USDA, ARS and the Plant Sciences Department at the University of Arizona, Tucson. As a barley breeder he is interested in developing IPVA (identity preserved, value added) cultivars. ARS

and the University of Arizona have released a cultivar, "Azhul," which has about twice (10-11%) the Beta-glucan content of commercial cultivars. One breeding program involves developing high-yielding naked cultivars that have a high Beta-glucan content. Another breeding program involves developing high-yielding cultivars with 45-50% amylose (as opposed to about 25% in commercial cultivars). Dr. Ramage is studying the inheritance of seed shape and size. This information may be of value in developing cultivars for specific uses such as pearling and flour milling.

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Mr. Ruark is the Vice-Chairman of the National Barley Improvement Committee and is directly involved in helping direct the efforts toward the betterment of barley--in both the production and usage of feed and food type barleys on a national level. As past member of the Washington Barley Commission, he had similar responsibilities, plus marketing on a state, national and international basis. His areas of interest are (1) the reutilization, revamping, and updating of the National Feed Composition Data Bank; and (2) the formation of a centrally coordinated barley food research effort that is U.S. wide, utilizing existing researchers, and funded by multiple funding sources.





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Dr. Satter is the Director of the U.S. Dairy Forage Research Center, a USDA-ARS laboratory on the University of Wisconsin campus. The Center's mission is to build a knowledge and technology base for the dairy industry to fully exploit the use of forages in the production of milk. The Center has agricultural engineers, plant and soil scientists, microbiologists, ruminant nutritionists and a chemist working together to increase the efficiency of forage production and utilization by dairy farmers. Dairy diets require supplementation with grain and protein sources, and characteristics of the starch and protein contained in grain sources can have important impact on how well they function as supplements. For example, protein from grain sources should be somewhat resistant to hydrolysis and deamination in the rumen (first compartment of the ruminant stomach). On the other hand, starch utilization is usually better if it is less crystalline. Waxy mutants of corn or milo are utilized slightly better than non-waxy mutants. Steam flaking of starch can improve starch digestibility. Dr. Satter's research interests are primarily in the area of protein utilization by ruminants, but he also has some interest in the role that starch supplements have in high forage dairy diets.

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Dr. Keith Schertz is a geneticist with the USDA Agricultural Research Service, Southern Plains Area. His interests are sorghum genetics and germplasm research with emphasis on reproductive characteristics. He is now integrating conventional approaches with molecular.

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Dr. Schillinger is the Executive Director, Agronomic Research at Asgrow Seed Company. He is responsible for providing, through innovative and integrated R&D programs, superior products for worldwide agronomic markets. His primary areas of emphasis include developing proprietary products supported with a breeder seed maintenance program; establishing R&D policies; developing strategic plans; interacting with the public sector, commodity groups and professional organizations. Currently, Dr. Schillinger is exploring means to add value to agronomic seed through alliances with other companies.





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Dr. Lew Smith is the USDA, ARS National Program Leader for Animal Nutrition. In this position, Dr. Smith is responsible for the relevance of the ARS Animal Nutrition Program for Food Producing Animals. Before coming to his current position, Dr. Smith conducted research on improving the use of forages and wastes and research on factors influencing the digestion and passage of plant cell walls.

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As the Director of Product Development and Regulatory Affairs for Microbial Genetics, A Division of Pioneer Hi-Bred International, Inc., Dr. Soderlund's responsibilities include overseeing the development of microbial products for agricultural purposes and working with the regulatory agencies to register those products. His purpose in attending this workshop is to represent Pioneer Hi-Bred as a company nutritionist. As one of the leading plant genetic companies in the world, Pioneer is very interested in discussing the future direction that traditional plant breeding and biotechnology will have on determining the nutrient composition of grains and

forages. His primary interest is in livestock feed production relating to protein and carbohydrate nutrition.

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Dr. Steele is a Research Leader in the USDA, ARS, Livestock & Poultry Sciences Institute, Non-Ruminant Animal Nutrition Lab. His interests include empiric diet formulation to optimize lean tissue growth (*i.e.*, *swine/poultry*).

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Dr. Ullrich, a Professor at Washington State University, Department of Crop and Soil Sciences, is a barley breeder and geneticist involved in cultivar development and fundamental aspects of barley genetics, biotechnology and barley grain quality. He has been especially interested in end use quality of barley -- malting, brewing, feed and food. He has done considerable work with barley composition analysis and variation especially relating to protein, amino acids, fiber and beta-glucans.



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Dr. Fran Webster is a Principal Scientist with the Quaker Oats Company. His primary responsibility is to coordinate the development of a technology base in oat biotechnology. Activities are focused upon RFLP mapping, transformation systems, disease resistance mechanisms and gene regulation and expression. The secondary objective is to aid in the integration of the technology into conventional breeding programs in order to accelerate the development of high quality and yielding oats. Specific areas of interest include grain quality factors, which encompasses all aspects of milling performance, functionality in food products and nutritive value.

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Dr. Wesenberg is a Research Agronomist and Research Leader with the USDA, ARS Small Grains and Potato Germplasm Research Unit, National Small Grains Germplasm Research Facility, Aberdeen, Idaho. His research and interests are concerned with the improvement of oat and barley

germplasm, including the nutritive value of these crops. Specific interests in this area include hullless oat improvement, groat content of hulled oats, beta-glucan and protein content of oats and barley, and the relationship of these nutritive traits to agronomic traits. Dr. Wesenberg is involved in cooperative research and evaluation of barley and oat germplasm for beta-glucan, protein, and other nutritive traits and the cooperative evaluation of the feed value of barley and oats, especially hullless oats.

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As a Research Geneticist with the USDA, ARS Field Crops Research Unit at Iowa State University in Ames, Iowa, Dr. Wright's interests and responsibilities include mutation breeding of corn, enhanced vitamin and amino acid content, and better starch processing characteristics.







## BACKGROUND/OBJECTIVES

The story of plant improvement is truly one of success. Further, the tools available to affect this improvement are becoming increasingly powerful. With the exception of milling and baking quality in wheat, grain quality in rice, and malting quality in barley, however, genetic improvement of cereal grains has focused upon "defensive" traits which protect the plants from diseases, insects, and environmental stresses. Recognizing both the need to "add value" to cereal grain production and the opportunity to bring emerging technologies to bear on that objective, this workshop was convened to explore opportunities to design unique ideotypes of corn, sorghum, oats, and barley to meet specific feed and food demands.

If these objectives are to be met, it is essential that there be effective communication between plant breeders and those with expertise in feed and food technology and in animal nutrition. This workshop brought together a representative group of scientists from the Agricultural Research Service, state universities, and private industry. Their charge was to (1) explore opportunities to design crops for specific uses, (2) describe specific ideotypes for these uses, and (3) determine a strategy whereby the benefits of this workshop can be further magnified. Traditional traits used by plant geneticists are still important, the challenge is to expand and reprioritize the list.

## OPPORTUNITIES

### Oats

The concept of designer ideotypes is not new to oat geneticists but most planning and research has been focused upon food uses. The number of modifiable traits available in this crop, the range of known genetic diversity, and the basic nutritional desirability of oats makes this an inviting crop for genetic improvement. Among the significant points which emerged from the discussion were:

- o It is unlikely oats will have significant use as feed for ruminant animals.
- o Oat protein is similar in quality to corn with the opaque 2 gene.
- o Hullless oats are a useful option for some designer ideotypes.
- o Significant genetic variability is available for oil quantity and (probably) quality.
- o Potential traits for oat improvement include:
  - Protein (Amino acid balance)
  - Oil (Fatty acid balance)
  - Fiber (Soluble and insoluble)
  - $\beta$ -Glucan
  - Groat content (relative to hull)
  - Digestible energy



- Antioxidants (tocols and non-tocols)
- Vitamins
- Minerals
- Lipase, Lipoxygenase
- Starch
- o Potential specialty uses considered were:
  - Human food
  - Animal feed
    - Nonruminants
      - Poultry
      - Swine
      - Horses
    - Pets and other small animals
  - Industrial uses
    - Oil
    - Starch
- o Potential oat ideotypes (*Table 1*)

TABLE 1 - Oat Ideotypes

TRAITS							
USE	Protein %	Oil %	Groat %	$\beta$ -Glucan %	Antioxidants % of Oil	Vitamins	Minerals <sup>a/</sup>
Human Food	S	3-4	75 or 100	9+	20-25	Inc. Niacin	
Animal Feed							
Poultry	S	10-15	100	S	20-25	S	
Swine	S	10-15	100	3.0-3.5	20-25	S	
Horses	S	10/17	75	S	20-25	S	
Aquaculture							
Cold Water	20+	15	100	3.0-3.5	20-25	S	
Fish							
Oil	20+	17+	75 or 100	S	S	S	
Potential Range	13-24	3-20	67-75/100	3-9	10-25		

<sup>a/</sup>Reduce phytate phosphorous  
S=Satisfactory

### Barley

Much is known about the composition of barley. This is a result of the close attention which is paid to quality in malting barleys. Unfortunately, though, little attention has been paid to the genetic improvement of barley for feed or food uses. Among significant points which arose during the discussion were:





- o Digestibility of barley starch is slower than that for other cereals; e.g., rice or wheat. This property (termed Glycemic Index) is very desirable for normal populations as well as for diabetics.
- o Increasing  $\beta$ -glucan content should be a major target because it is associated with both decreased cholesterol levels and a decreased rate of starch digestion.
- o Hull-less barley will be a desirable target for human food uses.
- o Potential barley ideotypes were identified and are indicated in Table 2.

TABLE 2 - Barley Ideotypes

TRAITS							
USE	Protein Qual.	Protein Quant.	Fiber	Starch	Phytate	Hulls	Tocotrienols
Feed							
Ruminant				Reduce rate of starch digestion			
Non-Ruminant							
Swine	Increase		Decrease		Decrease	Hull-less	
Poultry	Increase		Decrease			Hull-less	
Pet Food		Increase				Hull-less	
Human Food			High $\beta$ -Glucan			Hull-less	Increase

### Sorghum

Key points raised during the sorghum discussion included:

- o The vast majority of U.S. sorghum production is utilized for animal feed (primarily for cattle).
- o Sorghum competes directly with corn as an animal feed, thus a primary objective is to develop sorghum hybrids which are equal to or better than corn in feeding value.
- o Starch digestion (utilization) is the primary trait needing improvement to increase feed value.



- o Soft, floury sorghums may have increased digestibility but they are unlikely to be grown widely because of low density, poor resistance to weathering and other problems.
- o Among the quality characteristics discussed were:
  - Tannin
  - Endosperm characteristics
  - High lysine
  - Pericarp color
  - Uniformity
- o Targets for genetic improvement of sorghum are less specific than those for oats or barley. The primary breeding objectives identified were:
  - HIGH STARCH DIGESTIBILITY
  - INCREASED LYSINE METHIONINE AND THREONINE
  - WHITE PERICARP
  - HARDER ENDOSPERM

### Corn

The discussion regarding corn quality (composition) factors included a summary of the economic factors associated with upgrading feed quality through the addition of commercial additives. Two schools of thought emerged. Some felt that genetic improvement of protein quality was generally not worth the effort--because most feed additives are quite cheap. Others felt that saving even a few cents on feed costs would be meaningful to livestock producers and that breeding for the best possible composition was desirable.

A listing of some potential value-added traits includes:

- o High lysine (opaque 2, floury 2, multiple aleurone)
- o Waxy endosperm
- o High vs. low protein content (26.6% vs. 4.4%)
- o High vs. low oil content (16.6% vs. 0.4%)
- o Amylose extender
- o Shrunken-2 (super sweet corn)
- o Cob corn (pipes)
- o Corn nuts (large, soft kernels)
- o Grits (hard, white endosperm)
- o Resist microbial toxin formation
- o Improved milling characteristics (both wet and dry)
- o Improved oil composition (high oleic acid)

The workshop generated what was considered a reasonable set of corn ideotypes (TABLE 3).





TABLE 3 - Corn Ideotypes

TRAITS						
USE	Oil Quantity	Protein Quantity	Protein Quality	Mold Resistance	Digestibility	Hardness
Feed						
Poultry	Increase	Increase	Increase	Decrease	Increase	
Swine	Increase	Increase	Increase	Decrease	Increase	
Dairy	Increase	Increase	Increase <sup>a/</sup>	Decrease	Increase	
Beef	Increase	Increase	Increase <sup>a/</sup>	Decrease	Increase	
Wet Milling	Increase (decrease for byproducts)			Decrease		
Dry Milling				Decrease		Increase
Export				Decrease		

<sup>a/</sup>Increase ruminant bypass protein.

### STRATEGY

This workshop involved a relatively small number of scientists, many of whom had not met previously. It was never envisioned that the workshop would be an end unto itself. Rather, it was hoped that a seed of interest, *in new areas of collaboration and genetic improvement*, would be sown and that those present would all look for ways to magnify the impact of the workshop. No "magic bullet" strategy was identified but several important thoughts did surface, including:

- Feed composition databases do not reflect the wide diversity in composition of grains. A modern interactive database for feed composition is needed to document current ranges in composition and monitor progress toward achieving the desired nutrient content of grain.
- Research administrators need to promote cooperative interactions between plant breeders and both human and animal nutritionists (*recognizing that such collaboration is just as important as collaboration with pathologists, entomologists, statisticians, chemists, etc.*).
- Those with an interest and commitment to improve these value-added traits need to look for opportunities to organize lectures, symposia, and



workshops within their own societies, work groups, departments, etc.

- ARS will continue to look beyond its own research programs in this area and try to identify opportunities to facilitate Federal, State, industry interactions.
- There is current political interest in "value-added products" but a common tendency to assume the value will be added after agricultural commodities leave the farm gate. The participants in this workshop are well positioned to "educate" others of the potential to add value to the actual farm produce.
- It is of the utmost importance that users (whether those feeding livestock or those manufacturing food products) understand the powerful tools plant geneticists now command, and their ability to generate "designer crops" to meet their needs.





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